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Flexibility and strength training in asthma: A pilot study

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ABSTRACT

Objective: Although less is known about musculoskeletal factors that may contribute to asthma symptoms, body-based treatments addressing movement restrictions of the chest and shoulders may be a useful adjunct to asthma pharmacotherapy. In this pilot study, we compared asthma symptoms, pulmonary function tests, and medication use before and after a course of resistance flexibility and strength training (RFST) treatments in human subjects with asthma. **Methods:** Patients with asthma ($n = 10$; mean age 23 years) completed questionnaires (Asthma Control Questionnaire (ACQ), Asthma Quality of Life Questionnaire (AQLQ), Asthma Control Test (ACT)), spirometry, chest wall excursion, and shoulder range of motion (ROM) before and after a series of four RFST treatments over 47 ± 21 days. Each treatment consisted of a one-hour session involving eccentric stretching of the arm, shoulder, and chest while lying in a supine position. **Results:** Significant clinical improvement was observed for mean ACQ scores from pre- to post-treatment (mean decrease 0.73, 95% CI 0.26–1.09, Cohen $d = 2.25$, $p = .0014$). No significant improvement was observed in the ACT, AQLQ, or spirometry, although inhaler use decreased for half of the subjects and did not change for the remaining subjects (i.e. none increased). Chest wall excursion and all ROM tests trended toward improvement, but was only statistically significant ($p < .05$) for the arm raise in the frontal plane. **Conclusion:** RFST may be a beneficial, nonpharmacological method to decrease asthma symptoms. Future studies should be conducted involving a larger sample size, longer intervention time, control group, and blood collection to test inflammatory mediators.

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Introduction

In 2015 approximately 5% of people worldwide and 8% of people in the United States were affected by asthma making it one of the most common chronic diseases (1, 2). Although medication is available, adherence to asthma pharmacologic therapy has been reported to be low and asthma symptoms are often not well controlled (i.e. compliance of 50% in Europe, 30–70% in the United States) (3, 4). Nonpharmacological interventions have long been used as an adjunct to pharmacotherapy in the management of asthma. Prescribed interventions typically include aerobic exercise and/or breathing retraining exercises aimed at reducing hyperventilation, slowing, and regulating the breath by prolonging the expiratory phase, enhancing abdominal/diaphragmatic breathing, and imposing resistance on both inspiration and exhalation (5, 6). Patient perception of breathing training has been positively viewed, as it is nonpharmacologic, holistic, unobtrusive, and likely gives patients

more confidence in managing asthma symptoms (7). For similar reasons, breathing exercises derived from yoga, also termed “pranayama” exercises, are also gaining in popularity among asthmatic patients (8–15), in addition to more traditional breathing exercises and retraining techniques (5, 16–21). However, approaches that focus on breathing might miss an important opportunity to address musculoskeletal factors that could contribute to asthma symptoms.

Breathing retraining does not typically include attention to posture and dysfunction of the chest wall and shoulder girdle musculature, including chronic shortened (or lengthened) muscles and associated connective tissues. It is well recognized that the pathophysiology and symptomatology of asthma are complex and extend beyond the lung to involve psychosocial factors and neuroimmune stress responses (22). It is also clear that the uncomfortable sensations experienced by asthma patients during an exacerbation are complex and have

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strong affective overlays (23). Although the typical chest “tightness” described by asthmatic patients is believed to be primarily due to bronchoconstriction (23), the possibility that dysfunction and “tension” of skeletal muscles may contribute to this sensation of tightness has received little attention. The diaphragm and intercostal muscles are used in breathing, and depending on the degree of respiratory effort, other muscles can participate as well, including classical accessory muscles of breathing (sternocleidomastoid and scalene) and some less commonly recognized including: serratus anterior and posterior, pectoralis major and minor, trapezius, latissimus dorsi, levatores costarum, transversus thoracis, and subclavius (24). These same muscles are involved in maintaining posture, as well as performing voluntary movements of the trunk, neck, and shoulder girdle. A study comparing subjects with and without asthma found that asthmatics had more postural abnormalities including forward head and shoulder position, lower chest wall expansion, decreased shoulder internal rotation, decreased thoracic spine flexibility, and muscle shortening (25). Although these musculoskeletal and postural dysfunctions might be a consequence of asthma, it is also possible that they contribute to its disease manifestations. If this is true, correcting posture and improving muscular function might lead to an improvement of asthma symptoms.

So far, current physical therapy practice and research have given little attention to manual therapies applied to the chest wall and upper extremities. Resistance Flexibility and Strength Training (RFST) is a nonconventional physical technique specifically aimed at correcting postural misalignment by applying resistive force while eccentrically contracting muscles to stretch dense fascia and scar tissue (26, 27). Thus, the patient performs an eccentric contraction of extensor muscles when the joint is flexed or of flexor muscles when the joint is extended. In this relatively simple technique, the combined externally applied torque exerted by the practitioner and the eccentric contraction performed by the patient act in concert to stretch the connective tissues, both within and surrounding the muscle. In the upper body, this technique uses the arm as a lever to stretch the muscles and connective tissues of the chest wall.

The aim of this initial pilot study was to test the feasibility of RFST treatment on ten human subjects with asthma and compare responses to asthma-related questionnaires, pulmonary function tests, and medication use before and after a course of RFST treatments. Treatment consisted of four one-hour sessions performed one-on-one with a trained practitioner over a five-week period. We hypothesized the treatments would be well tolerated and would result in symptomatic improvement. Additional exploratory tests included measurement of range of motion of the chest and shoulders. Importantly, because this was a nonrandomized pilot study, we did not aim to test whether any improvements in response to RFST could be due to placebo effects or other factors (28).

Materials and methods

Study design

The study was approved by the Brigham and Women’s Hospital Institutional Review Board (IRB #2014P000994). This uncontrolled case series study evaluated the feasibility and compared metrics before and after RFST treatment in people with asthma. Subjects underwent two testing sessions, before and one week after the last RFST treatment (Figure 1). At each testing session, subjects completed questionnaires, spirometry, exhaled nitric oxide, and range of motion testing (ROM). Subjects had four RFST treatments over 47 ± 21 days, each consisting of a 45-minute one-on-one session with a certified practitioner. RFST was an add-on therapy to a subject’s current asthma regimen.

Human subjects

Inclusion criteria: 1) males or females aged 18–65, 2) physician-diagnosed asthma, 3) currently taking asthma medications, and 4) ACQ > 1.25.

Exclusion criteria: 1) smoking history of ≥ 10 pack years, 2) pregnancy or lactation or subjects planning to become pregnant during the course of the trial, 3) inability to communicate in English and 4) major medical problems prohibiting study participation (i.e. presence of chronic or active lung disease other than asthma or



Figure 1. Study design.

history of unstable significant medical illness other than asthma or concurrent medical problems that would place the participant at increased risk as determined by the study physician).

Subject profile: Symptomatic asthmatics ($n = 11$; mean age 23, range 19–29) were recruited by the Asthma Research Center (ARC) at Brigham and Women's Hospital and consented to be in the study.

Questionnaires and tests

Questionnaires: The subjects were asked to complete the Asthma Control Questionnaire (ACQ), the Asthma Control Test (ACT), and the Asthma Quality of Life Questionnaire (AQLQ) which are validated methods to measure asthma severity and quality of life (29–32).

Spirometry: All pulmonary function testing including forced vital capacity (FVC), forced expiratory flow (FEF max), FEV 1 (forced expiratory volume), FEV 1% predicted, and exhaled nitric oxide was performed according to ATS guidelines at the Asthma Research Center at Brigham and Women's Hospital (33). Exhaled nitric oxide (FeNO) was measured online by chemoluminescence at a constant expiratory flow (50 mL/s), consistent with published guidelines (34).

Range of Motion Measurements (ROM): Assessment of posture through range of motion measurements was performed at the first and last study visits for the following tests (Figure 2).

Shoulder mobility (SM): This test was adapted from the Functional Movement Screen (35). For a right-arm measurement, the subject was asked to make fists with their thumbs inside, then raise the right arm over and behind their head, and flex their left arm behind their back. The subject was instructed to try to touch their fists together. The distance between the fists was recorded.

Posterior arm extension (PAE): The subject faced the wall with their toes, stomach, and nose touching it. A goniometer was placed at the top of the shoulder with the eye of the goniometer at the junction of the deltoid and trapezius muscles. One end of the goniometer was aligned with the neck, the other with the arm. The arm angles were recorded.

Arm raise in frontal plane (ARF): The subject's heels, back, and head were against a wall. The subject was instructed to raise one arm at a time, keeping that arm's wrist and forearm in contact with the wall while reaching up as high as they could. The goniometer arm was placed in line with their arm and the other end perpendicular to the floor. The eye of the goniometer was approximately at the humeral lesser tubercle/scapular coracoid process. Angles were recorded.

Axillary Chest Circumference (ACC): Chest circumference was taken while standing with a tape measure just below the armpits. Measurements were recorded for baseline (normal breathing), maximal exhale, then maximal inhale. ACC excursion was calculated as the difference between maximal inhale and exhale. The axillary and xiphisternal chest circumference measurements have been reported to have good reliability for intraclass correlation (36) and have been used as an outcome measurement in several studies (37–40).

Xiphoid Chest Circumference (XCC): Chest circumference was taken with a tape measure at the level of the xiphoid process. Measurements were recorded for baseline (normal breathing), maximal exhale, then maximal inhale. XCC excursion was calculated as the difference between maximal inhale and exhale (21, 38).

Practitioner

One practitioner administered all treatment sessions. The practitioner received six months of supervised training in the RFST technique under the supervision of Robert Cooley (Boston, MA) and has been in private practice since 2007. RFST is a physical therapy technique in which a certified practitioner extends or flexes a joint while the subject actively resists the motion applied by the practitioner (Figure 3). More specifically, the practitioner holds a patient's extremity(s), then flexes or extends the limb(s), instructing the patient to resist the flexion or extension produced by the practitioner. The patient is in control of how much resistance is applied at all times; for this study, resistance was never applied so strongly that it was painful. A typical full body course of RFST



Figure 2. Range of motion testing method. A: Shoulder mobility; B: Posterior arm extension; C: Arm raise in the frontal plane.

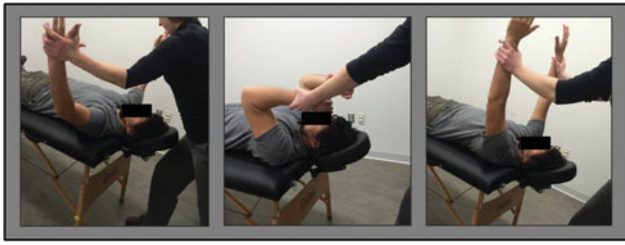


Figure 3. Resistance flexibility and strength training (RFST) stretching method examples: The practitioner extends or flexes a joint while the subject actively resists the motion applied by the practitioner.

treatment consists of 4–20 sessions held 1–2 times per week. In the current study, the intervention consisted of four treatments over 47 ± 21 days.

RFST treatment focused on the chest and upper extremities. While the subject lay in a supine position on a massage table, the practitioner varied the angle of the forearm and shoulder, focusing on areas that had greater resistance (a feeling of stickiness and/or jerkiness felt by the practitioner). The subject was asked to focus on “lengthening” the limb (not “locking in”) while actively resisting the practitioner’s hand (typically placed at the longest part of the subject’s extremity). Balancing the left and right sides by the practitioner was achieved before focusing on strength gains. The process was repeated 2–15 times for each movement sequence.

Statistical analysis

Paired t-tests were used to evaluate changes in mean scores on asthma questionnaires (ACQ, AQLQ, ACT), spirometry results, and outcome measures associated with chest wall excursion and shoulder range of motion (ROM). McNemar’s test was used to test for directional change in inhaler use which was measured as an ordinal response variable. Effect sizes (ES) were based on Cohen’s d defined as $\mu_d / \sigma_{\text{baseline}}$, where μ_d = mean change and σ_{baseline} = baseline standard deviation. This definition allows for the estimated effect sizes to be comparable to the ones computed for a parallel group design (53, 54). Post hoc power calculations based on the observed

correlation between pre- and post- scores resulted in estimated power of 80% (two-sided $\alpha = .05$) to detect mean changes of 30%, 16%, and 18% for ACQ, ACT and AQLQ scores respectively. Analyses were performed using SAS statistical software Version 9.4 (SAS Institute, Cary, NC).

Results

All reported results reflect pre- versus post-RFST treatment comparison.

Subject retention and adverse events

Ten of the eleven subjects completed the four RFST treatments. One subject dropped out due to change in geographic location. One subject experienced mild lightheadedness when going from a lying to standing position which resolved within one minute. No subjects reported any other treatment side effects including transient muscle soreness.

Questionnaires

Significant clinical improvement was observed for mean scores on the ACQ from pre- to post- treatment (mean decrease 0.73, 95% CI 0.26–1.09, Cohen $d = 2.25$, $p = .0014$) (Figure 4A, Table 1). ACT and AQLQ scores were on average improved by 2.00 and .78 respectively post- vs. pre- treatment, although these differences were not statistically significant ($p = .10$ and $p = .06$ respectively) (Figures 4 B,C, Table 1). Inhaler use (ACQ) decreased for five of the ten subjects and did not change for the remaining five subjects (i.e. none increased). There were no adverse events throughout the duration of the study.

Spirometry

FEV 1 and FVC improved slightly post-treatment, but these changes were not statistically significant ($p = .08$ and $p = .07$ respectively) (Table 1).

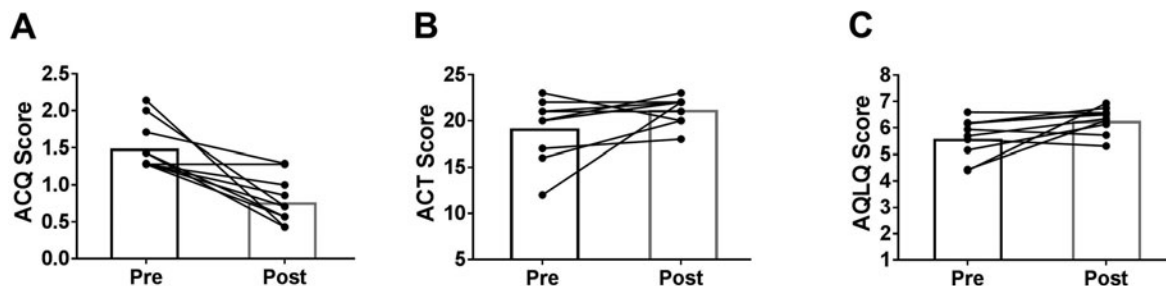


Figure 4. Results: A: Asthma control questionnaire; B: Asthma control test; C: Asthma quality of life questionnaire.

Table 1. Clinical scores and measures of pulmonary function.

Test	N	Pre treatment		Post treatment		P value	Cohens-d
ACQ score	10	1.5	± 0.1	0.8	± 0.1	.001*	2.24
ACT score	10	19.2	± 1.0	21.2	± 0.5	.10	.61
AQLQ score	10	5.6	± 0.2	6.4	± 0.2	.06	1.04
Exhaled NO (ppb)	10	28.5	± 5.8	33.3	± 7.8	.48	.26
FEV1 (L)	10	3.2	± 0.1	3.2	± 0.1	.08	.17
FEV1% predicted	10	91.4	± 2.7	93.4	± 2.5	.08	.23
FVC (L)	10	3.9	± 0.2	4	± 0.2	.07	.13
FEF Max	10	6.2	± 0.4	6.3	± 0.4	.44	.12

Values presented are mean ± SE

Chest circumference and range of motion measurements

There were no significant differences in chest circumference excursion (ACC, XCC), shoulder mobility (SM) or posterior arm extension (PAE) pre- vs. post- treatment. Arm raise in the frontal plane (ARF) increased on both left ($p = .02$) and right sides ($p = .07$), (Table 2).

Discussion

In this pilot study, RFST resulted in a clinically and statistically significant improvement in the ACQ (mean score decrease of 0.73), and smaller, nonsignificant improvements in the AQLQ and ACT questionnaires. This observed improvement in the ACQ was greater in magnitude than that previously reported for other non-pharmacological treatments including ACQ improvements of 0.1 to 0.6 for aerobic exercises (41–45), 0.2 to 0.3 for conventional breathing retraining (12, 46) and 0.1 to 0.4 for yoga or pranayama breathing exercises (15).

Patient adherence to RFST in our pilot study was excellent, with only one subject out of ten not completing the course of four sessions due to moving out of the geographical area (91% adherence). Previous studies using physical treatment modalities reported treatment adherence ranging from 73 to 95% for aerobic exercises (42–45, 47), 51 to 86% for conventional breathing retraining (12, 46), and 53 to 100% for yoga and breathing (9–11, 13, 15, 28).

The results of this study demonstrate that a series of four RFST treatments was feasible and well tolerated in

patients with mild to moderately severe asthma. However, another important consideration is that subjects only received the minimum number of RFST sessions based on typical clinical practice. Although adding more treatments may increase clinical benefits, we do not know whether or not adherence to treatment would drop off with a longer course of treatment. In addition to symptomatic improvement, pre- and post- treatment comparisons showed reduced inhaler use, although we did not observe any improvement in pulmonary function tests.

Because improvement in asthma symptoms without an accompanying improvement in spirometry is a typical finding with placebo treatments, a possible explanation for our results is that the observed improvement in asthma symptoms could be due to placebo effects (48, 49). Alternatively, it is possible that a significant improvement in spirometry was not observed because baseline pulmonary function tests were only mildly impaired in most of our subjects. Another possibility is that improved chest and shoulder girdle mobility after RFST may enhance aspects of breathing that are not captured by standard spirometry. This is supported by the observed increase in shoulder range of motion in the frontal plane that involves the pectoralis, serratus, and latissimus muscles which are a major muscular component of the chest wall. Reduced muscle “tension”, change in muscle length and/or increased compliance of connective tissue structures in the chest wall may reduce the sensation of chest “tightness” that is often described by patients with asthma and may coexist with anxiety. A reduction in these sensations may thus lead to improved scores in asthma-related symptom questionnaires. RFST could also alter the neuromuscular firing pattern of muscles involved with respiration, allowing breathing to become more efficient.

Another possibility is that stretching of tissues during the RFST treatments had anti-inflammatory effects. Recent research in animals has shown that stretching of connective tissue can promote the resolution of local tissue inflammation (50). Furthermore, specialized pro-resolving mediators can decrease allergic airways responses, and are linked to asthma severity and control (51, 52). It remains unknown whether stretching of

Table 2. Range of motion measurements.

Test	N	Visit 1		Visit 5		P value
ACC Excursion (cm)	9	4.2	0.4	5.0	0.5	0.15
XCC Excursion (cm)	9	4.1	0.6	4.8	0.6	0.14
SM-Left (cm)	9	8.5	± 2.3	8.5	± 2.9	0.99
SM-Right (cm)	9	9.6	± 3.1	8.1	± 2.6	0.07
PAE-Left(°)	9	38	± 3	40	± 4	0.38
PAE-Right(°)	9	35	± 3	38	± 3	0.26
ARF-Left(°)	9	151	± 8	165	± 6	0.02*
ARF-Right (°)	9	154	± 7	166	± 7	0.07

Values presented are mean ± SE.

musculoskeletal tissues produces systemic pro-resolution effects that may also affect the lung and airways.

A limitation of our study is that subjects were all young adults, and therefore we do not know if our findings would generalize to other age groups. Future studies could include both children and the elderly; this is important as the burden of chronic lung disease worldwide will continue to rise as the global population ages and effective, cost-efficient treatment will be important.

Conclusion

This pilot study suggests that manual therapies such as RFST may be a beneficial, nonpharmacological method to decrease asthma symptoms. Future randomized studies should be conducted involving a larger sample size, longer intervention time, appropriate control groups, EMG, and plasma collection to test inflammatory mediators.

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Declaration of interest

The authors declare no financial conflicts of interests.

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